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PROBABLY no period in the history of the country has created a greater demand for range research than the last decade. The acute economic situation since 1930, aided and abetted by drought, has caused many a stockman to look for the help which research results might afford. The efforts of Federal and State agencies to alleviate the situation has called for a vast amount of information which research techniques aided in collecting and research results facilitated in interpreting. The best indication of the part research may play in the solution of range problems lies in consideration, first, of the nature and scope of these problems, and second, of the gains in improved range conditions and the possibilities revealed for further improvement where research has already been developed and applied.

Range forage means much to the West. Approximately 65 percent of the feed for all livestock in that area is furnished by the 728 million acres of forest and non-forest range land. That forage, together with the integrated agricultural production, is carrying approximately 19 million cattle and 36 million sheep and goats for part or all of the year. These livestock produce 75 percent of the country's total production of wool and mohair, 55 percent of the sheep and lambs and nearly one-third of the cattle and calves.

The herbaceous and shrubby vegetation is the primary erosion control agent on untimbered range lands and on those forest lands supporting open stands of trees. Range lands also support a large population of big and small game and other wild life and have other aesthetic, inspirational and historical values.

FIFTY years of use and abuse have caused deterioration of a high percentage of range lands, greatly reduced wild life populations, impaired profitable livestock production, and left in its wake other serious social and economic problems. The

problem of restoration has important implications in land ownership and public acquisition, in public and private land administration, management, and control, in the better integration of range and crop agriculture, and finally in expanded programs for research and education.

Until the passage of the Taylor Grazing Act in 1934, the 142 million acres of the Federal unreserved public domain was a no-man's land used without restriction. Users overstocked it in an effort to discourage others. The inevitable result was excessive overgrazing and depletion of 67 percent in forage productivity, presenting a range restoration problem of the first order.

Private ownership of approximately 375 million acres of range land, including the most productive, presents several major aspects. A substantial portion of the private range areas owned or controlled by the larger well established experienced stockmen are reasonably well managed and are usually in good condition. Some small ranches are in similar condition. The balance is so depleted, that all private lands taken together show an average deterioration of approximately 50 percent. A vast area, close to a hundred million acres, made up in part of remnants of the alternate sections of railroad and other land grants, is intermixed with the unreserved public domain, has been subject to the same unrestricted use, and is in approximately the same depleted condition. Another large area, resulting from settlement under the several homestead acts, especially in the plains area, is in holdings too small for either successful management or a decent living. The inevitable result has been overstocking, range depletion, reduced production and bankruptcy. This situation has intensified the financial difficulties of all stockmen. Furthermore, the depletion of these small holdings has been accentuated by the attempt to cultivate millions of acres of what was once good range in the plains and foothills where rainfall is inadequate for farming.

SEVERAL agencies have been created in recent years to deal with various phases of these problems. Basic information has often been meager or lacking, and many phases of the work have had to depend on the best judgment available.

Thirty-three years of administration of the national forests, under a conservation objective, close cooperation with stock-

men, and a conscious effort to apply principles developed by research, afford the best obtainable indication of what research can do to meet such problems. On the 83 million acres of national forest land now grazed, range has been gradually improved and the stability of the dependent livestock industry has been increased. During this time national forest ranges, along with other ranges, have felt the deteriorating effect of drought and users have been confronted with serious economic problems.

National forests have been administered with a conservation objective and a conscious effort to apply research results.

These situations, together with the extensive emergency conservation programs have greatly intensified demands for facts, methods of restoration and other management principles which would aid in bettering conditions.

Range Research Development

Forest Service range research centers primarily on the range resource itself and is concerned with the handling of livestock only as this affects range utilization and other resource values. Emphasis is given to problems of regional and national importance.

Much of the research of the past has been aimed at answering problems pressing for immediate solution, answers to

which could be obtained by extensive surveys or short-time studies. These empirical studies developed numerous basic management principles and practices, including: (1) classifying specific range areas by the different classes of livestock for which they are particularly adapted; (2) determining the approximate grazing capacities of mountain range types, which in turn have shown the number of livestock which may graze on each range; (3) establishing suitable seasons for grazing the different elevational zones, particularly with respect to readiness of plants for grazing; (4) developing methods of management to control losses from poisonous plants; and (5) obtaining more even and more effective use of the available forage and preventing damage to the range by better distribution and handling of livestock and avoidance of trampling and localized overgrazing. Another early development was deferred and rotation grazing, now widely applied throughout the West. These early studies have been followd by intensification and by expansion to lower elevational types representative of other public and private ranges. Various phases are conducted in cooperation with other bureaus of the Department of Agriculture and with the State agricultural experiment stations.

THE plan of organization of forest and range research in the Forest Service in regional experiment stations under a director responsible for all phases within his region, has made it possible to head the range research staff of the region with a thoroughly competent man, to assure co-ordination of effort, interchange of ideas, and joint consideration of interrelated problems. It also facilitates the work by making available suitable reference, statistical, and other services that could not be economically maintained by smaller and more local units.

At present research in the Forest Service on range land problems is concerned primarily with five broad phases: range forage investigations, range management studies, experimental work in artificial revegetation, studies of the efficacy of range cover in watershed protection, and range economics. Progress made and the prospect of future results give a fair indication of what possibilities lie ahead for the scientist along these different lines of research.

Range Forage Investigations

Nearly every approach to the range problem is intimately

concerned with a knowledge of range plants, their identification, growth requirements, life history, other ecological relationships, and forage and other values. Considerable general information, largely observational, has been collected regarding the forage values of range plants, based upon the extent to which they are eaten by livestock. Similar observations of the habitat relationships of many of these plants have been made. Classification and description are well advanced. The range plant herbarium in the Washington office consists of approximately 80,000 specially annotated specimens, representing about 1,400 genera and 8,000 species and varieties, collected by about 1,200 Forest Service officers. This herbarium, although far from complete, is already the fullest collection of western American montane plants extant, and is also unique in the wealth of ecological, phenological, and economic data which accompany these specimens and thus facilitate correlation of data from different parts of the country. But the field, as yet unsurveyed, is vast, and detailed studies of growth characteristics, habits, requirements, physiological processes, including the chemistry of growth, reproduction, food storage, etc., of range plants and their reaction to grazing, have been made thus far for only a few of the most important plants of a few localities. Plans for future work include a more comprehensive and fundamental determination of just such features, the results of which will be invaluable guides in the broader range management studies and in applied research.

Range Management Studies

Since the demand for range forage for the number of livestock now in the western range territory far exceeds the supply, there is obviously urgent need for range management studies to develop methods of grazing, consistent with the conservation and use of other resources of the land, that will under the fullest possible use, restore and maintain the forage and produce livestock most effectively. Native range forage is relatively cheap compared to improved irrigated pastures on farms, hay and other supplements.

Such methods must, however, be adapted to forage condiconditions differing widely throughout the range country, these differences being intensified by various degrees of depletion, both of forage and soil, within each main forage type. Preliminary studies indicate that, if given the chance, the climax species in each type, generally desirable grasses

and other plants, will maintain themselves or even improve if not too closely grazed. In many cases, where forage or soil depletion is advanced, considerable time may be required for restoration. The development of management which will facilitate restoration of a better cover in such instances, accommodate the grazing demands to the greatest possible de-

Experimental reseeding plots on dry foothill ranges of central Utah.

gree, and yet harmonize with other resource values, requires study of all the involved factors as well as an understanding of the practical needs. This in turn requires a thorough understanding of the climatic, soil, moisture, and plant relationships, the physiological reaction of the different plants to grazing, and the influence of all this on the successional and other ecological trends of the plant cover.

Research must be extended speedily along three broad avenues: (1) the development or improvement of management principles; (2) the determination of some of the more important relationships between livestock grazing and other uses of the range; and (3) the development of fundamental research, basic to the management of the range resource.

The investigations which have been under way for nearly twenty-five years at the Jornada and Santa Rita Experimental Ranges, in New Mexico and Arizona respectively, in range management, especially in relation to severe drought illustrate the first phase. These experimental ranges show marked contrasts with heavily stocked unregulated range of potentially equal productivity. The grazing capacity on the managed range is double that of the unregulated, net calf production is more than half again larger, and death losses are only one-fifth to one-third. A profit of 8.8 percent has been earned on an investment of $69.23 per cow over the last eleven yeaors in an experimental herd on the Santa Rita Experimental Range.

Under the second phase, early studies of grazing in relation to timber production brought out the possibilities of damage to timber reproduction from too heavy or unseasonable grazing and indicated major adjustments required. More recent investigations by the Southwestern Station of the relationships between frequency of watering livestock and damage to young growth of ponderosa pine are making possible the use of properly stocked range without undue injury to timber reproduction. Only a meager beginning has been made, working out a balanced relation between domestic livestock grazing and wildlife conservation. The increasing numbers of wildlife, however, greatly intensify the need for a full understanding of this relation.

Under the third phase a good beginning has been made in determining the competitive relationships, response to climate and soil, and other requirements of the associations of range plants in a number of localities. This has been especially true in the mountains of central Utah and on semi-arid ranges of the Southwest. The further development of these fundamental studies in all important range types of the West gives greatest promise of progress in the betterment of range management.

Artificial Revegetation

The principal objective of research in artificial revegetation is to develop low-cost methods and suitable species for seeding or transplanting on nearly 40 million acres of range lands, often abandoned cultivated fields, now so badly depleted that reasonably rapid natural revegetation appears improbable. Both forage and watershed values are at stake.

Approximately 600 tests throughout the West have indicated that there is little chance for improving the bulk of native range lands in their present condition by the introduction of the common cultivated forage plants although success with them has been obtained where soil and moisture conditions are especially favorable, such as depleted mountain meadows. Several plants which meet the requirements desired for revegetation, in that they seed readily, produce abundantly, withstand moderately close grazing, and thus maintain a stand, have proven successful in seedings of the relatively dry foothill and plains ranges in Utah, Idaho and Montana.

A station has recently been established in co-operation with the Bureau of Plant Industry and the Utah State Agricultural College at Logan, Utah, to study the selection and breeding of plants suitable for forage and watershed protection on range lands and to study adaptability of other foreign and native plants for this purpose. Plant breeding, selection, and hybridization hold untold possibilities in developing high-yielding and disease-resistant strains of native and introduced range vegetation, and the long hoped-for drought-resistant forage plants so urgently needed for restoration of range and watershed values.

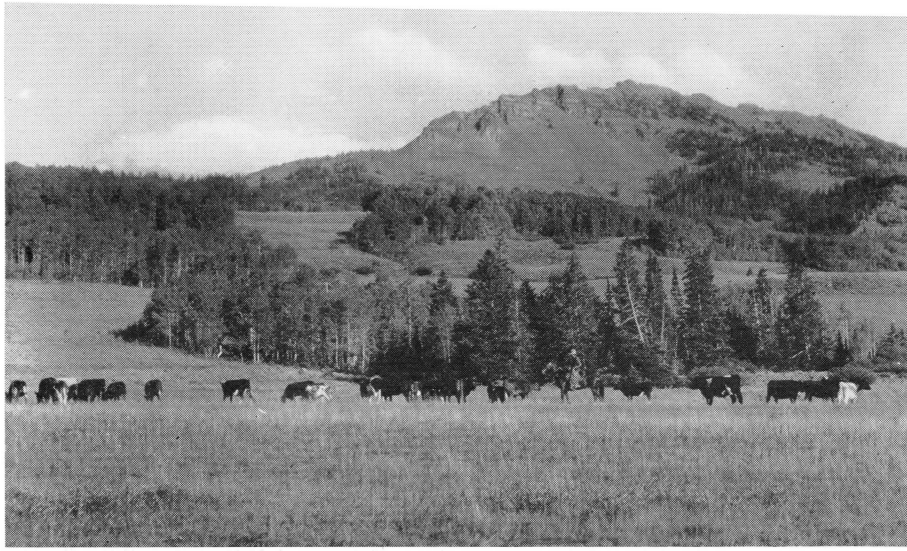
Progress is being made in the adaptation of grain drills to permit their use in seeding slopes with success at low cost.

The interest of stockmen and of the various agencies concerned with rehabilitation of abandoned fields on submarginal farm lands, erosion control, and range betterment is so great that more intensive fundamental studies of the revegetation problem in all parts of the West are urgent.

Watershed Protection

The watershed-protection research of the Forest Service on forest and range lands seeks to determine the fundamental principles of how plant cover controls erosion and streamflow and the extent to which the cover can be modified in beneficial use without damaging watershed values.

Intensive investigation of watershed protection on range areas throughout the West have increased our understanding of how depletion of cover has increased run-off and erosion, and reduced absorption of moisture by the soil. It has also shown the unusual value of grass cover in good condition in checking run-off and erosion. Using a portable rain-making apparatus and storms of two-inch per hour intensity, tests



have shown that the bunchgrass type, supporting an average cover density of but 35 percent, permitted only 0.4 percent of the rainfall to run off the surface and eroded only six pounds of silt per acre. The loose porous soil inter-penetrated with the fibrous root systems of the bunchgrass absorbed practically the entire precipitation.

Although restoration to a satisfactory condition is necessary, it will be, at best, a long and slow process in many areas if left to nature alone. Accordingly, definite data are needed concerning the most practical cover which can be obtained promptly for reasonably satisfactory watershed protection. The range cover on watersheds is so closely interrelated to the range livestock industry and the social and economic welfare of the West that additional research is required to determine how much the cover may be modified or utilized without sacrificing its ability to retard run-off, build and bind the soil, aid water percolation, and otherwise control erosion and stream flow.

Range Economics

One measure of the value of research is the net economic or social betterment which may result from application of the improved principles, methods, or practices. Reference has already been made to the profitable returns from improved range management on the Santa Rita Experimental Range. Similar determinations of the practical economic values of improved practices are made for most of the other principles developed by the research. In connection with national forest administration, studies have also been made of the value of

national forests to local communities, of what fees should be charged for grazing privileges, and of how the use of dependent private ranch lands can best be coordinated with grazing use of national forests. The latter problem is so complicated and changing economic conditions modify situations to such an extent that a much more adequate study of co-ordination of interrelated private and public range and ranch lands is now being undertaken in the Intermountain region. The field of range economics research has hardly been sampled as yet. It offers a wide opportunity to the student of range conditions and their place in local and national welfare.

What Is The Answer?

The solution of the many problems of range land restoration and use will demand large expenditures by private individuals and the public. Among other things, in providing better forage conditions to support the present debt structure, in overcoming submarginal settlement difficulties, in checking excessive erosion and floods, and in placing the use on a more sustained profitable basis. The expenditures for the Civilian Conservation Corps, for other phases of unemployment relief, for range conservation programs, and the losses in bankruptcy and in decadent communities loom large already.

Much development of the range industry of the West has been on the basis of rule-of-thumb with the inevitable wasteful use and destruction of a great natural resource and a certain degree of deterioration of human resources. Research, the determination and evaluation of facts and principles, to serve as a basis for developing public and private policies offers a much less costly means than continuing on a trial and error basis. Research to date has aided in understanding the prevailing situation and the seriousness of certain conditions. It has solved a few of the problems and pointed the way to possible solutions of others. The general application of improved practices has brought millions of dollars of savings and increased revenues to the livestock industry and has been a big factor in the improved conditions now found on national forests as compared with the average of other range ownership classes.

Progress to date, though marked, is but a bare start on the complicated problems of the 728 million acres of western ranges. During the next decade preliminary results will be

refined and additional studies will culminate and their results pass into practice. Studies should be extended into many important range areas not previously investigated, including the vast areas of native range forage in the pineries of the South and the woodland ranges of the Ozarks. Only through research can the full possibilities of livestock production, consistent with conservation of the forage and other land resources be attained at reasonable cost.

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